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MODIS SCIENCE TEAM MEMBER**Semi Annual Report (July - December, 1994)****Chris Justice (University of Maryland)****Eric Vermote (University of Maryland)****Jean-Claude Roger (University of Maryland)****Contract#: NAS5-31365****a) Task Objectives**

The objectives of this phase of the project were: to continue the research program developing the 'at-launch' algorithms for MODIS atmospheric correction, vegetation indices, fire detection and land cover and to build the infrastructure and collaboration to permit the research to be undertaken. The completion of the ATBD revisions and the development of the beta code were given a high priority. The project has developed a number of collaborative projects which are intended to expand the scope of the team members activities and involve a larger community in the MODIS research. Due to the small number of researchers addressing the issues necessary for the methodological advances needed for MODIS, emphasis has been given to developing international collaborative research and MODIS outreach through the IGBP Data and Information System Core Project. In addition, the goals of the MODIS project, the status of the instrument and preliminary results of the research were presented at key scientific meetings. The project was also represented at the MODIS Team meeting. Results of the studies undertaken as part of the project are in the process of being written up and submitted for publication.

3rd Quarter: July - Sept 1994**b) Tasks Accomplished (Data analysis and interpretation)**

Specifically the project has addressed the following topics over the last six months:

MODIS atmospheric correction:

- The 6S code: Version 3.2 is in preparation. Version 3.2 will remedy the bugs discovered in Version 3.1 as well as final improvements. A paper on 6S is in currently in preparation with D. Tanre which will

describe the Code and give the accuracy of the various simulations. Collaboration with the BRDF group (Alan Strahler) has been initiated to solve the circularity problem in atmospheric correction/ BRDF products. The approach selected will be tested on BRDF's fitted from Kimes (Code 923) measurement data set which are used as lower boundary conditions in simulations performed with the 6S code.

- Stratospheric aerosols:

An inversion scheme for stratospheric aerosols has been applied to NOAA7-9-11 data. Monthly stratospheric aerosol optical depth profiles produced from the El Chichon eruption inverted from AVHRR/NOAA7 data have been compared to SAGE data and very good agreement (+0.02-0.05 od units) has been found.

MODIS Airborne Simulator:

- A paper was presented on the atmospheric correction scheme applied to MAS data using the SCAR-A dataset. Retrievals of aerosol optical depth using the middle infrared channel, initially done at 0.670 micron, have been performed at 0.550 microns to test the characterization of aerosol type. In both cases, comparisons with sunphotometer measurements are good (+- 0.03 RMS). These results allow us to perform spectral BRDF studies (which are under analysis).

Sunphotometer Network Atmospheric Correction Validation:

-The proposal to NASA on LTER Atmospheric Correction received mixed reviews from excellent to poor. It is pending a programmatic decision with respect to funding. This proposal was intended to augment the MODIS pre-launch R&D activity exercising the operational atmospheric correction method on AVHRR and TM data using LTER located sun-photometer data as the validation. It is linked to the MODIS test site concept and a proposal using the corrected data for FPAR analysis is being written by Running and al.

- Prototyping with AVHRR and Sunphotometer data. Brazil sunphotometer network measurements (Holben 923) have been compared to automated retrievals using AVHRR data. The analysis of 3 months of results shows a very good agreement (better than 10%) between sunphotometer measurements and retrieved optical depths using the AVHRR-ch3 reflectance threshold method to identify dark pixels in channel 1.

MODIS Land Cover:

- Dr Justice attended the IGBP-DIS Validation Working Group Meeting on Land Cover in Cambridge UK. Initial discussions were held concerning the modification of the IGBP Land Cover product as the at-launch stratification of land cover to be used by MODIS.
- Discussions were held with Dr K. McGwire and EDC DAAC staff concerning the 1994-1995 Landsat Pathfinder GLCTS initiative.

MODIS Fire Detection:

- Luke Flynn (Univ. of Hawaii) was contracted to help in the Fire Algorithm development work. He participated in the SCAR C experiment and provided NASA Ames (MAS) with a calibration of their hotplate and light sources. These components are critical to obtaining useful MAS calibrations for the SCAR-C data. He has initiated a study to produce a MODIS prototype data set using a the Yellowstone Fire TM image (Sept. 8, 1988: when 1 million acres of the park was either burning or was a burn scar). He created the 1.5, 2.1, and 11 micron data sets, and is working on suitable assumptions for producing the 3.9 micron data set. He is currently working on the feasibility of discriminating between smoldering and flaming conditions using TM data.
- Work continued on the AVHRR fire algorithm - a comparison data set is being designed using DMSP and GOES data to examine the diurnal sampling aspects of MODIS data.

MODIS Vegetation Index:

- Examination of the atmospheric correction currently implemented as part of the AVHRR pathfinder processing used as an input to the VI product has revealed some bugs. Dr Vermote is currently working with the Pathfinder Staff to examine the implications.
- The MNDVI is being evaluated for a number of TM data sets currently held in house.

c) Data / Analysis / Interpretation

- Continued analyses of AVHRR, MAS and Landsat TM data were performed as part of the MODLAND prototyping effort.
- Work was started to develop the Beta Delivery Code and test data sets planned for delivery in early November. The Code will be based on the MAS data for testing and will include the Code to derive vegetation indices.

Meetings Attended

- Dr. ElSaleous and Vermote attended the Flathead meeting on Test data sets in September.
- Dr. Justice attended the EDC DAAC SWG in September.
- Dr. Justice attended the IGBP-DIS Land Cover Validation Working Group meeting in Cambridge in September.
- Dr. Vermote attended the Carbonaceous Aerosol Workshop in California in August

f) New Papers

Vermote, E. F., ElSaleous, N. Z., Kaufman, Y. J. and Dutton, E., Stratospheric aerosol perturbing effect on the remote sensing of vegetation: Correction method for the composite NDVI after the Pinatubo eruption. (Submitted in March to special issue of RSE).

Roger, J. C. and Vermote, E. F., Computation and use of the reflectivity at 3.75mm from AVHRR channels. (Submitted in March to special issue of RSE).

Vermote, E.F., and Kaufman, Y.J., Absolute calibration of AVHRR visible and near infrared channels using ocean and cloud views. (Submitted in Feb to Int. J. Rem. Sens).

Justice, C.O., Kendall, J., Dowty, P., and Scholes, R. J., Satellite remote sensing of fires during the SAFARI Campaign using NOAA AVHRR data. (Submitted to JGR)

Scholes, R.J., Ward, D., and Justice, C.O., Emissions of trace gases and aerosol particles due to vegetation burning in Southern Africa. (Submitted to JGR)

Huete, A., Justice, C.O., and Liu, H., Development of Vegetation and Soil Indices for MODIS. R. S. Env 49: 224-234.

4th Quarter: October - December 1994

b) Tasks Accomplished (Data analysis and interpretation)

Specifically the project has addressed the following topics over the last six months:

MODIS Atmospheric Correction:

-6S: Version 3.2 should be available on "kratmos" anonymous ftp site in the next month. Among other things, a modified absorption model, improved agitated ocean model (wind-speed, direction of wind, and water salinity), flexible aerosol parametrization (direct input of size distribution and refraction indices) will be available. A draft of a paper describing 6S in collaboration with the Laboratoire d'Optique Atmospherique (Lille-France) has been completed and will be submitted following a final meeting at Laboratoire d'Optique Atmospherique in Lille in February.

BRDF/Atmospheric Coupling:

A sensitivity study on the problem of coupling surface and atmospheric BRDF in the atmospheric correction scheme has been completed. Results showed the soundness of the proposed approach and that uncertainties outlined in the ATBD documents can be reduced to acceptable levels (0.005, reflectance units). Subsequent studies including synthetic dataset from MISR and MODIS, as well as real data (AVHRR) will be undertaken to validate and improve the approach. Emphasis will be on the examining the choice between a generic and simple surface BRDF model for the correction of the land atmospheric coupling effect.

Stratospheric Aerosols:

- A module for stratospheric aerosol correction has been included in the AVHRR-pathfinder code. Analysis of the results of the correction for this global dataset for Pinatubo effect will be investigated in the next few months.

-Analysis of AVHRR-Pathfinder Rayleigh / Ozone correction scheme problems has been completed, errors in the correction scheme have been documented and a code to re-correct the processed data has been produced.

MODIS Airborne Simulator:

- In the framework of the Beta Delivery, an internal processing system for MAS datasets has been achieved. Systematic analysis of atmospheric correction parameters produced by MAS inversion (aerosol, water vapor) is on-going.

Sunphotometer Network Atmospheric Correction Validation:

-The proposal to NASA on LTER Atmospheric Correction will be funded by NASA HQ. This proposal is intended to augment the MODIS pre-launch R&D activity exercising the operational atmospheric correction method on AVHRR and TM data using LTER located sun-photometer data as the validation. It is linked to the MODIS test site concept and a proposal using the corrected data for FPAR analysis submitted by Running and al.

POLDER Proposal on Calibration and V.I's:

The proposal "In flight vicarious Calibration of the POLDER instrument and quality assessment of POLDER vegetation monitoring capability" (P.I. Eric Vermote) was selected by the International POLDER science board, and was presented during the Land group sub-meeting to other P.I.'s. The presentation was very well received by the POLDER investigators. It was agreed that the proposed calibration is a crucial issue for remote sensing especially for POLDER that doesn't have any on board calibration system. A close linkage will be made between POLDER and MODIS with respect to algorithm development and testing work.

MODIS Land Cover:

Nothing to report.

MODIS Fire Detection:

Activities centered around the acquisition of data sets with which to test the MODIS Fire Algorithm. The first task was to serve as a Mission Scientist for the SCAR-C project. SCAR-C was very successful with a large amount of AVIRIS and MAS data collected over burning fires in California and the Pacific Northwest. Some fires were "prescribed burns" or pre-planned fires. The ER-2 carrying MAS and AVIRIS was able to cover some of these fires before, during, and after the main flaming stage and should result in excellent MODIS simulated data sets. The second task was to identify data sets to be converted to MODIS format for fire studies. AIRDAS and Landsat TM data were analyzed, and while AIRDAS does show promise in that one of its 4-channels is "the fire channel" (3.95 microns) and its detectors have very large dynamic ranges that do not saturate over

highly radiant fires, both the 3.95 and 11 micron channels have been observed to be "noisy". This is probably a result of the sandwiched detector design in which incoming radiation must pass through a narrow bandpass filter before striking the detectors. Landsat TM is much more promising for fire studies but it does not have a fire channel. For this reason, an IDL program was written to "create" a fire channel at 3.95 microns (MODIS channel 21 specifications were used) using Landsat TM Bands 5, 6, and 7. This program can easily be modified to create any MODIS IR channel data set from a Landsat TM Band 5, 6, and 7 image. A 15 km x 15 km Landsat TM image of the 1988 Yellowstone fires served as a test for the 3.95 micron conversion algorithm. This file will then be converted to MODIS 1km resolution using an algorithm developed by Kai Yang (Goddard). Plans are to convert a Yellowstone full scene to MODIS resolution using the two algorithms and then test the Fire Algorithm using this data set.

MODIS Vegetation Index:

The MNDVI was applied to selected TM images for evaluation.

c) Data / Analysis / Interpretation

- Continued analyses of AVHRR, MAS and Landsat TM data were performed as part of the MODLAND prototyping effort.
- Work was continued to develop the Beta 2 Delivery Code and test data sets planned for delivery in early 1995. The software for atmospheric correction and vegetation indices computations of MODIS (MOD09, MOD14) is being completed. The algorithms work with simulated MODIS data. Emphasis at this stage was given to the critical components of the algorithms and having a test data set that could be used with the software provided. The data used with this code are in part real sensor data from the MODIS Airborne Simulator (MAS) acquired during Sulfate Clouds Aerosol and Reflectance (SCAR-A) field experiment and in part simulated or synthetic data for the MODIS channels which were absent from the MAS instrument used during SCAR A (ie. the 0.47 μ m, 1.24 μ m, 1.6 μ m channels). The data set for input to the software consists of 7 MODIS bands and the necessary Level 3 ancillary data: for aerosols, water vapor, ozone, elevation. The MODIS vegetation indices (ie. NDVI, MNDVI) are generated using the atmospherically corrected data. Level 3 products will not be contained in the code. The plan will be to deliver a Beta 3

code which will approximate the MODIS data code which will include Level 3.

Meetings Attended

Dr. Justice attended the IWG and SWAMP meetings in Baltimore in October.

Dr. Justice coordinated and attended the At-Launch DEM meeting at NASA / HQ in October

Dr's. Justice, Vermote and Roget attended the MODIS Team Meeting in October.

Dr. Justice attended an EOS Desk Top Computing Environment Meeting in November.

Dr. Justice attended an interagency Biomass Burning (fire) Research Strategy Meeting in December.

Dr. Vermote attended the First POLDER Science Meeting in December.

Dr. Vermote and Roget attended a European meeting in Rome "Satellite Remote Sensing" and presented 3 papers to be published in the proceeding of the meeting in October.

d) Anticipated Future Actions.

Research:

Beta 2 Code Delivery

Atmospheric Correction

AVHRR Global Fire Analyses

VI integration with the atmospheric correction code

MAS development work

Upcoming Meetings:

BRDF/ATM Correction/Land Cover Meeting (Jan)

IGBP Land Cover WG meeting (Feb)

MODLAND / SDST Meeting (April)

Hardware Purchase

e) Problems/Corrective Actions

Nothing to report

f) New Papers

The IJRS Special Edition on AVHRR data sets which includes the MODLAND paper has been published.

-Vermote, E. F., El Saleous N., "Stratospheric aerosol perturbing effect on the remote sensing of vegetation: operational method for the correction of AVHRR composite NDVI". In: Recent Advances in Remote Sensing and Hyperspectral Remote Sensing, Proc. SPIE, 27-29 September 1994, Rome.

-Roger, J. C., E. Vermote and El Saleous N, 1994: Atmospheric corrections of MAS data during SCAR-A experiment. In: Recent Advances in Remote Sensing and Hyperspectral Remote Sensing, International Soc. Opt. Engr., Rome, September 27-29,1994.

-Vermote, E. F., El Saleous N. and J.C. Roger "Operational atmospheric correction of AVHRR visible and near infrared data". In Recent Advances in Remote Sensing and Hyperspectral Remote Sensing, Proc. SPIE, 27-29 September 1994, Rome

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